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Contract n° DAJA45-90-C-0052
Report No. RD 6146-MS-01.

Contractor :

METZ University, Faculty of Sciences
Laboratory of Physics and Mechanics of
Materials, METZ, FRANCE

Research project :

Experimental Investigation of Adiabatic Shear Banding at Different Impact Velocities

Principal Investigator : J.R. KLEPACZKO

2nd Interim REPORT
from : Jan. 19, 1991 to : May 18, 1991

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Contract Number : DAJA 45-90-C-0052

Title of proposal : **Experimental Investigation of Adiabatic Shear Banding at Different Impact Velocities**

Report Number : 02/91
Period covered : Jan. 19/91 to May 18/91

Name of Institution : Metz University, Faculty of Sciences, Laboratory of Physics and Mechanics of Materials, Metz, France

Principal Investigator : J.R. KLEPACZKO

ABSTRACT

Within the interim period, Jan. 19- May 18, 1991, a new experimental technique to study adiabatic shear bands at different displacement velocities has been pursued. The technique is in its early stage of development, i.e. the mechanical parts have been machined and the experimental setup has been assembled. The measuring techniques are in preparation.

The principles of the new technique have been published recently in a conference proceedings.

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1. The current status of the project

Within the framework of the research contract entitled "Experimental Investigation of Adiabatic Shear Banding at Different Impact Velocities" (contract number : DAJA 45-90-C-0052), the following activities have to be reported :

i. The air gun, dia. : 22 mm, has been put into operation and the measuring system of the projectile velocities works without problems (fiber optics, time counters and digital oscilloscope) ;

ii. The mechanical part of the new experimental setup has been machined (transmi tter tube, measuring heads, projectiles) ;

iii. At present, the mechanical part of the setup is under assembly (bench, transmitter tube, measuring heads and optical extensometer).

In order to understand the assembly and the principles of the new experimental technique, a short description of the details are given below .

2. The new experimental technique.

Although the Split Hopkinson Torsional Bar (SHTB) is very useful in high strain rate testing, the main drawback is that due to a finite risetime of the incident wave (usually ~ 30 μs) and small maximum angle of rotation (usually ~ 30°), the maximum shear strain of a tubular specimen is insufficient for many materials to reach critical value for adiabatic instability. Also the rate of loading is very limited.

In order to avoid those difficulties, a new experimental configuration with a modified specimen geometry of double shear has been developed in LPMM Metz. The schematic of experimental setup is shown in Fig. 1. The double shear flat specimen is loaded directly by a long projectile which can be accelerated to a desired impact velocity by the gas gun ($1 \text{ m/s} \le V \le 100 \text{ m/s}$). Impact velocity is measured by the source of light, fiber optics 1, 2, 3, photodiodes F and two time counters TC_1 and TC_2.

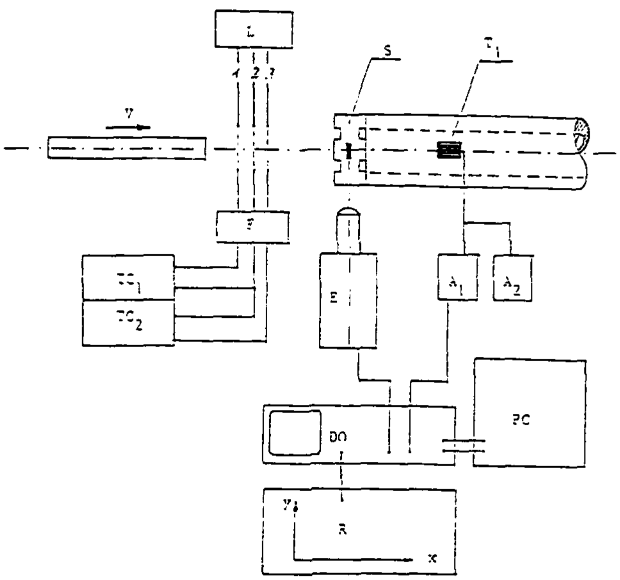

Fig. 1 : New configuration of experimental setup developped in LPMM Metz ; P - projectile ; S - double shear specimen ; L - source of light ; 1, 2, 3 - fiber optics ; F - photodiodes ; TC1,TC2 - time counters ; E - optical extensometer ; T_1 - strain resistance gage ; S - DC supply unit ; A_1 - amplifier ; DO - digital oscilloscope ; PC - microcomputer ; R - XY recorder.

Axial displacement $U_x(t)$ of the central part of the specimen is measured as a function of time by an optical extensometer E. Axial force F(t) is determined as a function of time from the transmitter wave $\varepsilon_T(t)$ measured by strain gages T_1, DC supply unit S_1 and amplifier A_1. All electric signals are recorded by digital oscilloscope DO and next stored in personal computer memory PC. In addition, a hard copy is produced with XY recorder R. The experimental setup permits for a wide variation of the nominal strain rate $\dot{\Gamma}_n$, 5 x 10^2 s^{-1} $\leq \dot{\Gamma}_n \leq$ 5 x 10^4 s^{-1}. Direct determination of the axial displacement permits for a more exact calculation of the deformation history. After elimination of time force-displacement curve can be constructed and next $\tau(\Gamma)$ and $\dot{\Gamma}(\Gamma)$ curves. The experimental setup based on the principle discussed above is quite effective and flexible for testing of adiabatic catastrophic shear. Further studies are pursued, especially to evaluate dispersive effects of elastic waves in tubes. This problem stems form the fact that at high impact velocities duration of the transmitted wave is of the order 1.0 μs to 20 μs.

A preliminary study on experimental techniques used in testing of adiabatic shear bands has been already published (J.R. Klepaczko, Adiabatic Shear Bands, Review of Experimental Techniques and Results, in : Mechanics, Numerical Modelling and Dynamics of Materials, Aniversary Volume LMA, Marseille (1991), 335).

3. Current activities.

A direct contact has been established between the Principal Investigator (J.R. Klepaczko), Chief of Materials Dynamics Branch, Materials Technology, Watertown, Ma. (S.C. Chon) and Head of the Etablissement Technique Central de l'Armement (Y. Remillieux).

It has been decided that the first series of specimens to be tested will be steels provided by ETCA.

Because of the limited funds, it has been decided to buy a new oscilloscope Hewlett-Packard, Model 54510 A, instead of Nicolet which is much more expensive. The HP 54510 A oscilloscope is fast enough to record transmitted waves in the transmitter tube (sampling rate ~ 1 Gs).

The main problem is at present caused by departure of our technician who was responsible for the mechanical part of project. The search for another technician is in progress.